REMARKS

This Amendment is filed in response to the Office Action dated September 29, 2004. For the following reasons this application should be allowed and the case passed to issue. No new matter is introduced by this amendment. The amendment to claims 1, 5, and 8 is supported by the specification at page 3, lines 8-16 and FIG. 2. Support for new claims 9, 14, and 16 is found in originally filed claim 2 and page 3, lines 16-18. New claims 10 and 17 are supported by page 6, lines 19-21. New claims 11 and 18 are supported by the specification at page 12, lines 1-19. The specification at page 3, lines 12-21 and page 8, line 27 to page 9, line 1 supports new claim 12. Support for new claim 13 is found in page 11, lines 8-11 of the specification. The specification supports new claim 15 at page 10, lines 5-17.

Claims 1 and 3-18 are pending in this application. Claims 1-8 have been rejected. Claim 2 has been canceled. Claims 9-18 are newly added.

Interview Summary

Applicants gratefully acknowledge the courtesy Examiner Sheehan in granting a telephone interview with the undersigned on November 10, 2004. During the telephone interview Examiner Sheehan explained that because this application and Ser. No. 10/809,422 share four common inventors: Tetsurou Tayu, Hideaki Ono, Makoto Kano, and Munekatsu Shimada, and Ser. No. 10/809,422 contains two additional inventors: Yoshio Kawashita and Takeshi Yamauchi, it is necessary to identify the inventor(s) of the conflicting subject matter. The Examiner further explained that we should identify the inventor(s) of the conflicting subject matter in the next response. For example, a statement to the effect, "The inventors of the conflicting subject matter in U.S. Patent Applications Serial No. 10/600,602 and Serial No.

10/809,422 are (list the appropriate inventor(s)' names) would be sufficient. Applicants thank Examiner Sheehan for his helpful recommendations.

Claim Rejections Under 35 U.S.C. § 112

Claims 1-8 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite. The Examiner asserted that it is not clear how the mixture of particles in claim can be described as a magnet. Further, the Examiner averred that it was not clear what is meant by "forming the mixture" in claim 5. These rejections are traversed, and reconsideration and withdrawal thereof respectfully requested.

Applicants assert that the originally filed claims would have been definite to one of ordinary skill in this art. However, in order to advance prosecution of this application, claims 1, 5, and 8 have been amended to address the Examiner's asserted informalities. Applicants submit that the instant claims fully comport with the requirements of 35 U.S.C. § 112.

Claim Rejections Under 35 U.S.C. § 102

Claims 1-8 are rejected under 35 U.S.C. § 102(b) as being anticipated by each of Ghandehari (U.S. Patent No. 4,762,574), Japanese Patent Publication No. 2002-064010 (Japan `010), or Japanese Patent Publication No. 2000-082610 (Japan `610). These rejections are traversed, and reconsideration and withdrawal thereof respectfully requested.

A rare earth magnet of the present invention has a sintered body including rare earth magnet particles; and a rare earth oxide being present between the rare earth magnet particles, the rare earth oxide being represented by a following general formula (I):

R_2O_3 (I)

where R is any one of terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.

The rare earth magnet of the present invention has a feature that **the rare earth magnet particle is composed of a cluster of numerous fine crystal grains**. Because of this feature, it is possible to enhance coercive force of the rare earth magnet. Further, when the rare earth oxide is present between the rare earth magnet particles composed of a cluster of numerous fine crystal grains, the rare earth oxide functions as an insulation material, and electrical resistance of the rare earth magnet is significantly enhanced.

A method of manufacturing the rare earth magnet of the present invention is composed of a step of forming a rare earth magnet particle constituted by a cluster of numerous crystal grains, a step of preparing a mixture including the rare earth magnet particle and a rare earth oxide, a step of filling the mixture in a molding die; and a step of molding the mixture.

Ghandehari, Japan '010, and Japan '610 disclose rare earth magnets having a rare earth oxide. However, these references fail to disclose rare earth magnets having rare earth oxide and a rare earth magnet particle constituted by a cluster of numerous crystal grains, as required by independent claims 1, 5, 8.

The factual determination of lack of novelty under 35 U.S.C. § 102 requires the disclosure in a single reference of each element of a claimed invention. *Helifix Ltd. v. Blok-Lok Ltd.*, 208 F.3d 1339, 54 USPQ2d 1299 (Fed. Cir. 2000); *Electro Medical Systems S.A. v. Cooper Life Sciences, Inc.*, 34 F.3d 1048, 32 USPQ2d 1017 (Fed. Cir. 1994); *Hoover Group, Inc. v. Custom Metalcraft, Inc.*, 66 F.3d 399, 36 USPQ2d 1101 (Fed. Cir. 1995); *Minnesota Mining & Manufacturing Co. v. Johnson & Johnson Orthopaedics, Inc.*, 976 F.2d 1559, 24 USPQ2d 1321 (Fed. Cir. 1992); *Verdegaal Bros. v. Union Oil Co. of California*, 814 F.2d 628, 631, 2 USPQ2d 1051 (Fed. Cir. 1987). Because Ghandehari, Japan '010, and Japan '610 do not disclose rare earth magnets having a rare earth oxide and a rare earth magnet particle constituted by a cluster

of numerous crystal grains, as required by independent claims 1, 5, and 8; Ghandehari, Japan '010, and Japan '610 do not anticipate claim 1.

Applicants further submit that Ghandehari, Japan '010, and Japan '610 do not suggest the claimed rare earth magnet, method of manufacturing a rare earth magnet, and motor.

The dependent claims, including new claims 9-18, are allowable for at least the same reasons as the independent claims from which they depend, and further distinguish the claimed invention.

For example, claims 9, 14, and 16 further require that a size of the crystal grain constituting the rare earth magnet particle is 500 nm or below. New claims 10 and 17 further require that the size of the crystal grain is not greater than a single-domain grain size. The claimed crystal grain size of the rare earth magnet of the present invention provides high coercive force.

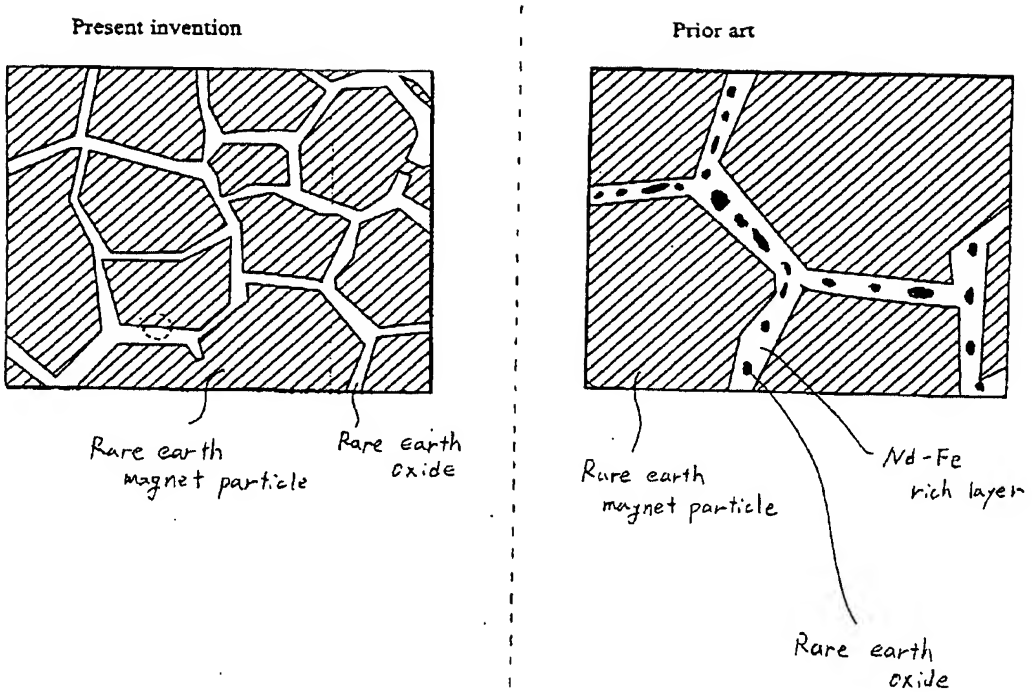
Japan '610 discloses that isotropic and anisotropic powders formed by HDDR method can be used as a raw material for the magnet (see column 4, para. [0017]). The manufacturing methods of Ghandehari, Japan '010 and Japan '610, require heating the magnet at 1000°C or more (Ghandehari: column 4, line 32-33; Japan '010: column 6, para. [0026]; Japan '610: column 6, para. [0022]). However, when the magnet is heated at 1000°C or more, the rare earth magnet particles of the rare earth magnet coarsen, and the rare earth magnet particles cannot be maintained within the range from 1 μm to 500 μm, as required by claims 9, 14, and 16. This phenomenon is well-known by a person having a ordinary skill in the art. If the size of the rare earth magnet particle is greater than 500 μm, the size of crystal grains is greater than a single-domain grain size and the rare earth magnet does not have high coercive force. Accordingly, the prior art process are unable to manufacture magnets as required by the instant claims. In

addition, the cited references fail to disclose that the size of the crystal grain is not greater than a single-domain grain size.

As regards claim 12, the rare earth magnet particle is manufactured by means of the HDDR method or UPSET method. These methods, provide rare earth magnet particles constituted by clusters of numerous crystal grains and rare earth magnets having high coercive force.

Furthermore, as required by claims 11 and 18, the rare earth magnet of the present invention has a protective film. Because the rare earth magnet is easily oxidized, the protective film on the rare earth magnet prevents the oxidization of the rare earth magnet.

As described above, the magnets of prior art references are heated at 1000°C or more. If a Nd-Fe-B magnet is heated at 1000°C or more, a Nd-Fe rich layer is produced as shown in following drawings (*see* K. Hiraga, M. Hirabayashi, M. Sagawa and Y. Matsuura: *Jpn.J.Appl.Phys.* Vol. 24 (1985) L30-L32) (attached). Even if the rare earth oxide is added in the Nd-Fe-B magnet, the oxide would dot in the Nd-Fe rich layer. The Nd-Fe rich layer has electrical conductivity, and thereby the conventional Nd-Fe-B magnet with the rare earth oxide cannot have a high electrical resistance. However, when the heating of the magnet is performed at 850°C or below, as required by claim 13, the Nd-Fe rich layer is not produced. Hence, by adding the rare earth oxide to the magnet composed of the magnet particles, the magnet obtains a significant electrical resistance. In addition, the manufacturing method of claim 15, which requires the MOCVD method, provides a magnet with a significant electrical resistance.



As discussed above, Applicants submit that Ghandehari, Japan '010 and Japan '610 fail to disclose and suggest the rare earth magnet and the manufacturing method of the present invention.

Obviousness Double Patenting

Claims 1-8 were provisionally rejected under the judicially created doctrine of obviousness-type double patenting over claims 1-17 of copending Application No. 10/809,422.

In response to this rejection, Applicants will file a terminal disclaimer.

Further, in response to the Examiner's comments in page 5, line 12 to page 6, line 4 of the Office Action, the inventor(s) of the conflicting subject matter in U.S. Patent Application Serial No. 10/600,602 and Serial No. 10/809,422 are Tetsurou Tayu, Hideaki Ono, Munekatsu Shimada, and Makoto Kano.

In light of the above Amendment and Remarks, this application should be allowed and the case passed to issue. If there are any questions regarding these remarks or the application in

general, a telephone call to the undersigned would be appreciated to expedite prosecution of the application.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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High Resolution Electron Microscopy of Grain Boundaries in Sintered $Fe_{77}Nd_{15}B_8$ Permanent Magnets

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Grain boundaries of sintered $Fe_{77}Nd_{15}B_8$ permanent magnets with different heat-treatments have been examined by high resolution electron microscopy. A b c c phase with the lattice constant of a=0.29 nm was found at most of the boundaries of $Fe_{14}Nd_2B$ grains. The b.c.c phase and $Fe_{14}Nd_2B$ grains are joined with smooth interfaces in the samples annealed at 870 K, which have a coercivity as high as 1000 KA/m. In samples quenched from 1350 K with a coercivity of about 500 KA/m, however, thin plates of the b.c.c phase extend from the interfaces to the inside of the $Fe_{14}Nd_2B$ grains, and deform the lattice spacings of (001) planes of the $Fe_{14}Nd_2B$ matrix. These thin plates are considered to act as nucleation centers of reverse magnetic domains which reduce the coercivity of the specimen.

§1. Introduction

Recently, Sagawa *et al.* reported that supreme hard magnetic properties could be obtained in Fe–Nd–B alloys based on $Fe_{14}Nd_2B$ with a new tetragonal structure. They succeeded in manufacturing a new sintered magnet having an energy product higher than that of permanet magnets commercially available.[1] The magnet has received much attention for its potential technological utility because of the high energy product and the relatively abundant resources of the elements of which it is composed.

The sintered magnet has the highest energy product at the composition of $Fe_{77}Nd_{15}B_8$ and the coercivity depends strongly on heat-treatments.[1] The magnet is a so-called nucleation type and the coercivity is thus mainly determined by ease of reverse-domain nucleation in regions with a low magnetocrystalline anisotropy. Such nucleation centers are grain boundaries, strongly disordered regions at lattice imperfections and precipitates.[2] Detailed examination of the microstructures of grain boundaries by high resolution electron microscopy is of interest, because the $Fe_{14}Nd_2B$ grains in the magnet appear to be perfect crystal grains containing few defects and no nucleation centers are expected to be formed within the grains.[3]

§2. Experimental Procedure

Samples of $Fe_{77}Nd_{15}B_8$ were sintered under an argon gas atmosphere at about 1350 K for 1 h and then quenched to room temperature. The intrinsic coercivity of the quenched samples was about 500 KA/m. The quenched samples were again annealed at around 870 K for 1 h to establish a higher coercivity of about 1000 KA/m. For

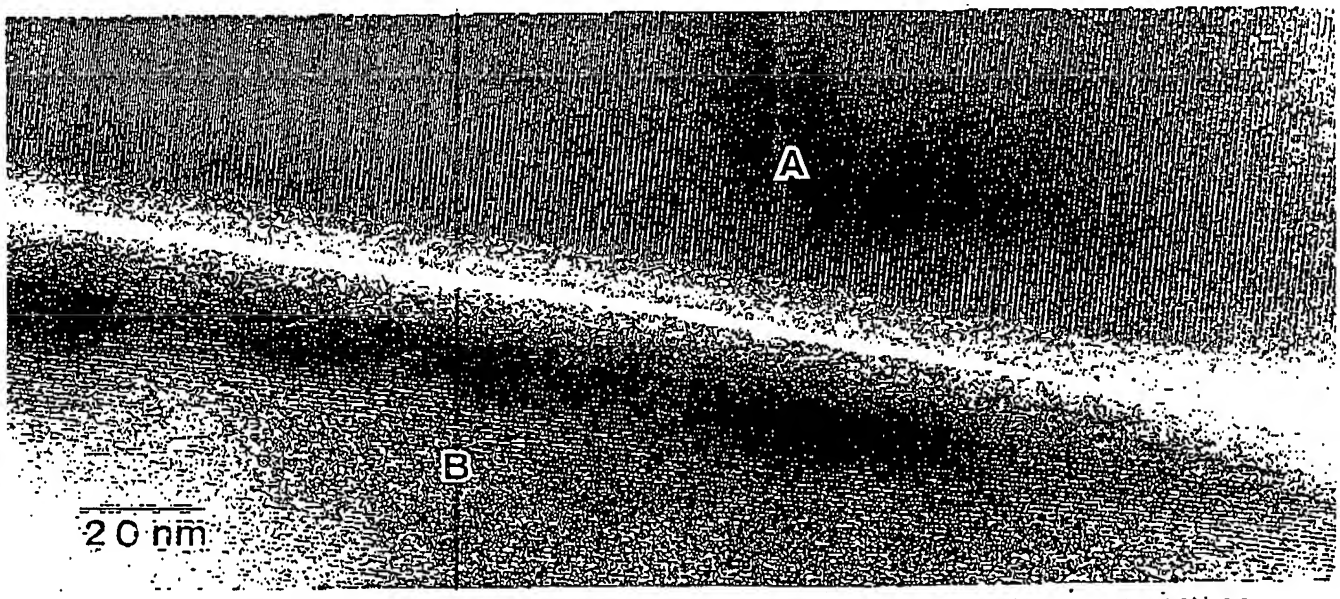

Fig. 1. High resolution image of boundary between $Fe_{14}Nd_2B$ grains in the sample annealed at 870 K showing a band of b.c.c phase appearing between the $Fe_{14}Nd_2B$ grains of A and B.

high resolution electron microscopy, thin foils of the quenched and annealed samples were prepared by a combination of mechanical polishing and ion-thinning. Observations were done using a 200CX type electron microscope (JEOL) with a top-entry goniometer

§3. Results and Discussion

The sintered $Fe_{77}Nd_{15}B_8$ magnet consists of three equilibrium phases, $Fe_{14}Nd_2B$, Nd-rich and B-rich.[3] In investigating many grain boundaries among the three phases, we found that most of the boundaries between $Fe_{14}Nd_2B$ grains were joined with a new phase with b.c.c. structure several ten nm in width and that their microstructures changed remarkably with heat-treatments.

Figure 1 shows a high resolution image of a typical boundary between $Fe_{14}Nd_2B$ grains in an annealed sample with a high coercivity. In the image, a band about 20 nm in width, without fringes, appears between the two $Fe_{14}Nd_2B$ grains of A and B which show fine lattice fringes. A bright line in the middle of the band is a region of absense of the sample due to selective sputtering dur-

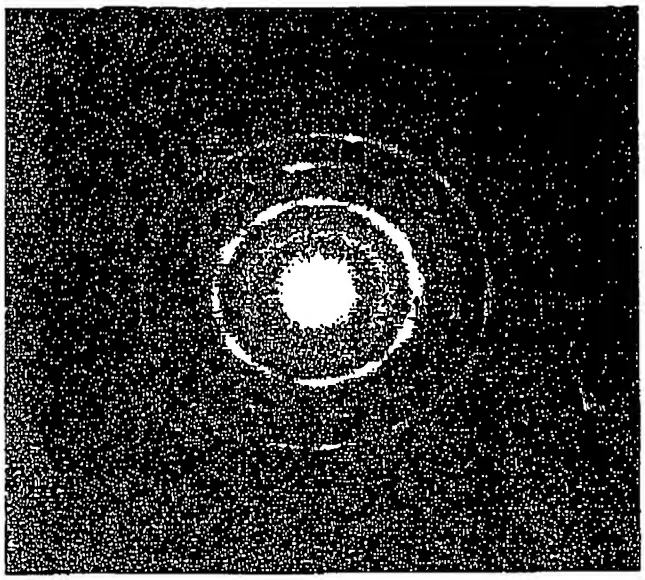

Fig 2 Selected area electron diffraction pattern from the band in Fig 1 The Debye rings indicated by arrows are indexed as 110, 200, 211, 220, 310, 222 and 321 for the b c c phase.

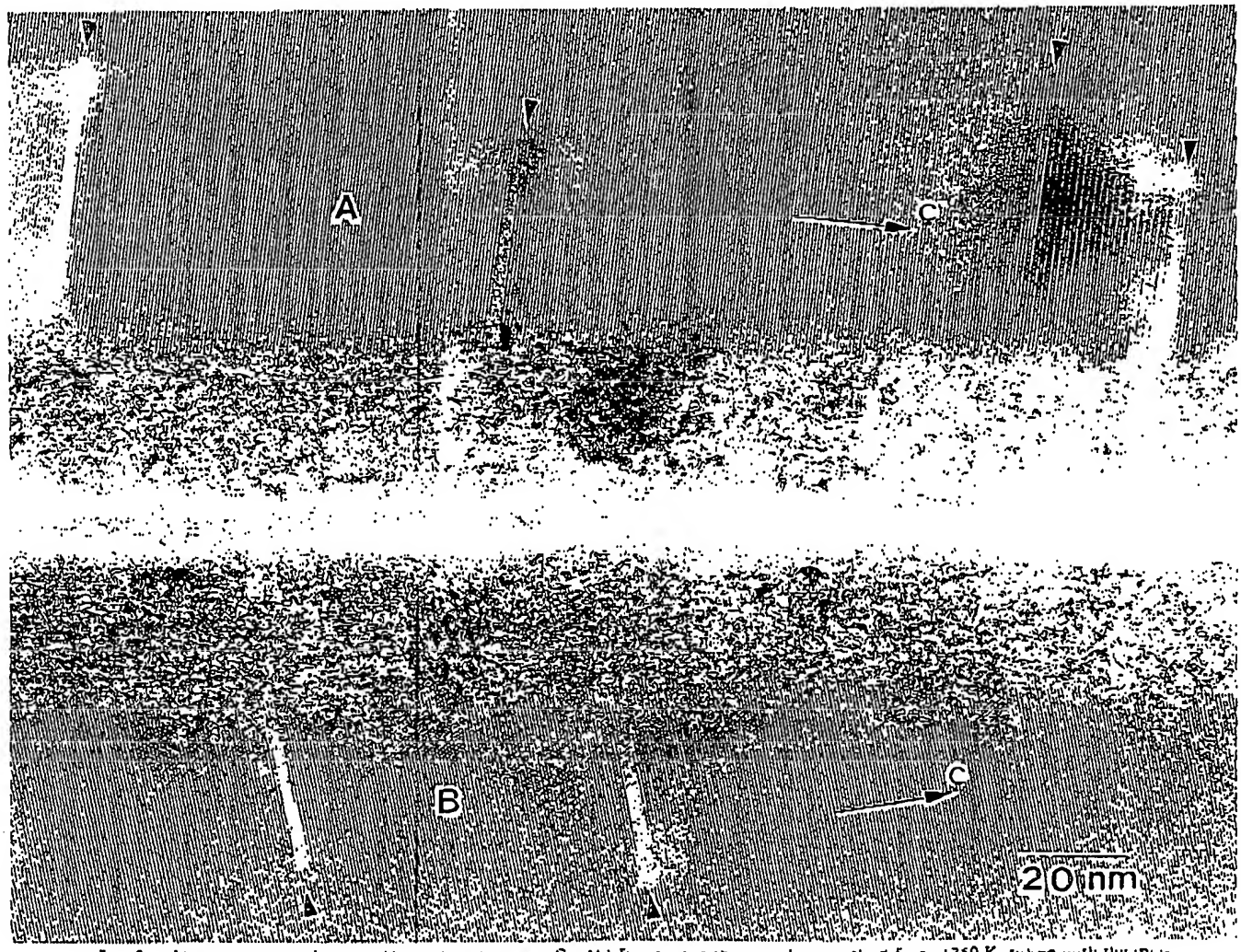

Fig 3 High resolution image of boundary between $Fe_{14}Nd_2B$ grains in the sample quenched from 1350 K, taken with the incident beam perpendicular to the c axes of the two $Fe_{14}Nd_2B$ grains A and B Arrows indicate thin platelets of the b c c phase

ing the ion-thinning process A selected area electron diffraction pattern from the band is shown in Fig. 2. The Debye rings marked by arrows in the pattern can be indexed in terms of a b.c.c. structure with the lattice constant of a=0.29 nm. In Fig. 1, we note that the boundary between the b.c.c. phase and the $Fe_{14}Nd_2B$ grain of A is distinct and straight in the edge-on view

In contrast, grain boundaries in a quenched sample with a low coercivity are not so simple as in the annealed sample, but show complicated microstructures (Fig. 3). The image is taken with the incident beam perpendicular to the c axes of the two $Fe_{14}Nd_2B$ grains A and B, so that the fine lattice fringes in both grains correspond to (001) planes with the distance of $c/2 \approx 0.6$ nm. There appear linear contrasts parallel to the fine fringes, as indicated by arrows. These are considered to be thin platelets of the b.c.c. phase extending from the boundary to the inside of the $Fe_{14}Nd_2B$ grains, the thickness of which correspond to a few basal planes of the $Fe_{14}Nd_2B$ structure A close examination of the image shows that the lattice fringes around the platelets are deformed with a compressive force along the c axis at the interfaces Deformation of the matrix lattices causes the reduction of magneto-crystalline anisotropy and the nucleation of reverse domains

§4. Summary

The results of the present investigation are summarized as follows. In the sample quenched from 1350 K, a number of thin platelets of the new b.c.c. phase, which are probably formed during the sintering and cooling processes, appear in the $Fe_{14}Nd_2B$ phase near grain boundaries and behave as nucleation centers of reverse domains which reduce the intrinsic coercivity of the magnet. After subsequent annealing at 870 K, the platelets disappear completely, and smooth and flat interfaces between the $Fe_{14}Nd_2B$ grains and the b.c.c. phase are formed. Therefore we conclude that the microscopic-morphology of the b.c.c. phase at grain boundaries plays an important role in obtaining the high coercivity of the sintered $Fe_{77}Nd_{15}B_8$ permanent magnet

Some details of the work will be published shortly elsewhere.

Acknowledgements

We wish to acknowledge the assistance of Kap Ho Lee in preparing the samples.

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